Evaluation of Knotweed Control Projects in Southwestern Washington

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Background:

Projects were funded by the State of Washington (administered through the Washington State Department of Agriculture) in July 2004 for on-the-ground control of introduced, invasive knotweeds (Japanese, Bohemian, giant, and Himalayan [*Polygonum cuspidatum*, *P. x bohemicum*, *P. sachalinense*, and *P. polystachyum*, respectively]) in southwestern Washington. All these species are currently listed as Washington state noxious weeds.

The objective of this project was to evaluate the effectiveness of herbicides for controlling Japanese and Bohemian knotweeds in these state-funded southwestern Washington control projects during fiscal year 2005.

Materials and Methods:

I monitored six sites to determine the relative effectiveness of the knotweed control strategies being conducted by the project managers at each location. Sites and treatments included the following:

Table 1. Overview of project sites and knotweed control strategies.

Project	Site	Knotweed Type	Treatment
Clark	Upper East Fork Lewis River	Bohemian	Injection, 5 mls Aquamaster per stem
Clark	Lower East Fork Lewis River	Bohemian	Foliar, 1.5% Habitat
Lewis	Upper Cowlitz River	Bohemian	Foliar, 1.5% Aquamaster + 0.75% Habitat
Pacific	Willapa River	Bohemian	Foliar, 2% Aquamaster + 0.5% Habitat
Skamania	Washougal River	Japanese (?)	Injection, 5 mls Aquamaster per stem
State Parks	Beacon Rock	Japanese (?)	Injection, 5 mls Aquamaster per stem

Permanent plots were established at all the sites listed above. Plots measured approximately 20 feet by 20 feet (400 ft^2), or as close to those dimensions as practical, given the various sizes and shapes of the knotweed infestations found at each site. Four plots were established at each site to provide for valid statistical analysis of control measures. Pre-treatment knotweed growth parameters were measured along two straight-line transects from opposite corners of each plot (e.g., from NW corner to SE corner, or from SW corner to NE corner). The number of stems produced in 2004 within

1.5 feet of either side of each transect line was recorded, as was the diameter of 10 of those stems at approximately 1 foot above the soil surface, selected randomly within the plot.

Plots were evaluated for spring knotweed re-growth during June, 2005. The overall percentage of knotweed control within each plot was visually estimated to the nearest 5% (0 = no knotweed injury, 100 = no knotweed present). Straight-line transects were again placed from opposite corners of each plot and the post-treatment number, height, and diameter of each living knotweed shoot found within 1.5 feet of either side of each transect line was recorded.

Data were analyzed using a general linear models procedure in a randomized complete block design. Individual plot data were the replicates, so each site contained four blocks, and a total of six sites were included in the analysis. Means were separated using Fisher's Protected LSD test (P = 0.05).

Results and Discussion:

Knotweed Control. Visual control of knotweed in treated plots did not statistically differ between sites and would be characterized as being good to excellent, ranging from 84 to 94% (Table 2). Herbicide choice or treatment type did not differ in their resultant level of knotweed control, although there was a trend toward improved control with foliar-applied Habitat (94%) compared to foliar-applied mixtures of Aquamaster + Habitat (90% averaged over two sites) or injection of 5 ml of Aquamaster (89% averaged over three sites). This indicates that knotweed vigor was probably more important than herbicide choice or manner of application at each site. Unfortunately, there was an inadequate mix of knotweed species among the treated areas to adequately separate species response from site or treatment responses. Therefore, specific recommendations for herbicides for particular knotweed species cannot be made based on these results. What can be said is that all these treatments provided demonstrably good knotweed control.

Table 2. Visual control of knotweed following treatment.

Site	Knotweed Species	Treatment	Rate	Control
				%
Upper East Fork Lewis River	Bohemian	Inject Aquamaster	5 ml/stem	93 a
Lower East Fork Lewis River	Bohemian	Foliar Habitat	1.5%	94 a
Upper Cowlitz River	Bohemian	Foliar Aqua + Hab	1.5 + 0.75%	92 a
Willapa River	Bohemian	Foliar Aqua + Hab	2.0 + 0.5%	88 a
Washougal River	Japanese (?)	Inject Aquamaster	5 ml/stem	90 a
Beacon Rock	Japanese (?)	Inject Aquamaster	5 ml/stem	84 a

Means followed by the same letter are not statistically different from each other.

Knotweed Stem Counts. Pre-treatment stem count (extrapolated to stems per acre) varied by site, ranging from a low of some 17,000 stems per acre on the Upper East Fork Lewis River to over 33,000 stems per acre on the Upper Cowlitz River (Table 3). Herbicide treatments reduced stem counts 63 to 80% across all sites, but because these reductions did not statistically differ, no particular herbicide recommendation can be made.

Table 3. Knotweed stem counts prior to and following treatment.

Site	Pre-treatment	Post-treatment	Reduction
	stems/acre	stems/acre	%
Upper East Fork Lewis River	17,235 c	4,613 b	73 a
Lower East Fork Lewis River	22,550 bc	6,406 ab	72 a
Upper Cowlitz River	33,507 a	6,577 ab	80 a
Willapa River	27,229 abc	7,623 ab	72 a
Washougal River	29,792 ab	10,763 a	64 a
Beacon Rock	19,731 bc	7,303 ab	63 a

Means followed by the same letter are not statistically different from each other.

Knotweed Stem Diameter and Height. Pre-treatment knotweed stem diameter also varied by site, ranging from 0.66 inch/stem on the Washougal River to 1.05 inch/stem on the Upper East Fork Lewis River (Table 4). Stem diameter was reduced 47% on the Washougal River, a statistically poorer reduction than what occurred on the Upper East Fork of the Lewis River, the Willapa River, or at Beacon Rock. This difference may not be particularly noteworthy, however, since the stems of knotweed plants on the Washougal were thinner to begin with. The 2005 stem diameters for all knotweed plants (except for the particularly impacted stems of knotweed on the Upper East Fork of the Lewis River) were quite similar, ranging from about ¼-inch to ¾-inch thick.

Post-treatment stem heights did not differ statistically among the sites (Table 4). Because of scheduling difficulties among personnel involved in these knotweed projects and me, the height of knotweed stems prior to treatment was not measured. Untreated stems outside these plots averaged heights of 72 inches or more by the June, 2005 evaluation, however. Average post-treatment stem heights of 9.7 to 20.2 inches in the plots, then, would correspond to minimum reductions of 72 to 87% from the heights of untreated knotweed.

General Observations on Knotweed Health. Re-growing knotweed stems generally were stunted (short internodes and small leaves), and many displayed abnormal growth consistent with expected herbicide symptomology. These symptoms included leaf chlorosis (yellowing/whitening of leaf tissues), abnormal leaf size and shape, abnormal branching of stems and masses of small branches at the nodes (witch's broom effect), and general stunting (reductions in height and diameter as noted in the data above).

Table 4. Knotweed stem diameter prior to treatment, and stem diameter and height following treatment.

Site	Stem Diameter			Stem Height[a]
	Pre-treatment	Post-treatment	Reduction	
	inches/stem	inches/stem	%	inches/stem
Upper East Fork Lewis River	1.05 a	0.14 b	82 a	9.7 a
Lower East Fork Lewis River	0.84 cd	0.34 a	60 ab	20.2 a
Upper Cowlitz River	0.75 de	0.28 ab	63 ab	15.9 a
Willapa River	0.87 bc	0.23 ab	74 a	13.0 a
Washougal River	0.66 e	0.35 a	47 b	18.4 a
Beacon Rock	0.96 ab	0.27 ab	72 a	16.2 a

[a]Height of knotweed stems prior to treatment was not measured; an average untreated stem would be expected to measure 72 inches or more by the date of evaluation.
Means followed by the same letter are not statistically different from each other.

Incidence of non-target injury was low (<10%, data not shown). Nearly all symptomatic plants in the June, 2005 evaluation were targeted knotweed. Injury to native salmonberry (*Rubus spectabilis*) and thimbleberry (*Rubus parviflorus*) and to weedy stinging nettle (*Urtica dioica*) and Himalayan blackberry (*Rubus discolor*) was noted, typically on the borders of treated areas, and occurring from foliar applications as well as from stem injection treatments. Injury levels were consistent with those observed at other knotweed control sites in many parts of western Washington. In all incidences observed from these southwestern Washington projects, the level of injury to non-target species was not severe enough to result in plant death. There also did not appear to be greater injury resulting from Habitat applications in comparison to treatments with Aquamaster, nor from foliar applications in comparison to stem injection.

Given that plots were located primarily in the center of large knotweed infestations, it is perhaps not surprising that little non-target injury was seen, since the number of non-target plants within the plots was quite small. In addition to the species listed above, most of these sites also contained mature native tree species such as red alder (*Alnus rubra*), black cottonwood (*Populus trichocarpa*), and bigleaf maple (*Acer macrophyllum*), as well as conifers such as Douglas fir (*Pseudotsuga mensiesii*) and western red cedar (*Thuja plicata*), all of which should provide seed to these sites after knotweed removal. It appears, then, that herbicide applications were specific enough to minimize injury to vegetation surrounding these knotweed infestations and rapid re-colonization of the site by these established species, both desirable and undesirable, will probably result.

There did not appear to be any knotweed seedlings in the plots at the time of evaluation; instead, all knotweed shoots arose from rhizomes or crowns of previously established plants. Since most of these sites were infested with knotweed plants that typically do not produce seed (presumably, only “male” Bohemian knotweed was present at four of the sites), this was not surprising. Two sites (Washougal River and Beacon Rock) were, however, apparently infested with female Japanese knotweed plants, as based on leaf morphology and heavy seed production noted on untreated plants in 2004. Still, knotweed seedlings were not obvious at either of these sites, providing a strong indication that seed production does not play a major role in knotweed reproduction in Washington.

It should also be noted that there was very little plant growth of any kind within treated areas. It is not clear whether this is due primarily to the herbicides used to control the knotweed or from the lack of species occurring within densely-growing knotweed infestations, but I suspect the latter is more important. Continued sampling of the vegetation occurring within these plots over the coming months, particularly in light of the knotweed re-treatments that will occur this summer, should help to answer this question.

Conclusions:

Visual knotweed control resulting from a single herbicide application applied in the summer of 2004 was excellent at about one year after treatment, averaging 90% over all sites and applications. No statistical differences were observed between treatment types, so injections of Aquamaster, foliar applications of Habitat, or foliar-applied combinations of Aquamaster + Habitat appear to result in similarly high levels of knotweed control.

Many of the knotweed stems re-growing on treated sites displayed herbicide symptoms consistent with the herbicides used, as well as severe reductions in their growth parameters as compared to pre-treatment levels. Across all sites, post-treatment knotweed infestations displayed a 71% reduction in stem count, a 66% reduction in average stem diameter, and an estimated 78% reduction in stem height. Reductions in these growth parameters indicate that while knotweed was severely injured by these herbicide treatments, repeat applications will be necessary to eliminate knotweed from these sites.

Finally, given the lack of observable knotweed reproduction via seed within the plots and the observation that surrounding vegetation was not greatly injured by these herbicides applied to knotweed, it is likely that re-colonization of these sites should occur rapidly and, in most cases, without the necessity of re-introducing desirable, native plant species.